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BULLETIN No. 625

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W. J. SPILLMAN, Chief

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CROPPING SYSTEMS FOR THE MOISTER PORTION OF EASTERN WASHINGTON AND OREGON AND NORTHERN IDAHO.

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CLOVER IN THE ROTATION TO ELIMINATE SUMMER FALLOW.

WITHIN the region adjacent to the Bitter Root and Blue Mountains in Washington, Oregon, and Idaho live more than 12,800 farmers who operate approximately 1,875,000 acres of improved farm land. The farms on which these farmers live have an annual rainfall of 20 inches or more, and have a black silt loam soil underlaid by a clay-like subsoil which is very retentive of moisture. The land has been devoted to the growing of wheat, oats, and barley, by the summer-fallow system, for more than 30 years.

A farm survey made in 1915 on 246 farms in a representative portion of the above described area showed that 30.2 per cent of the rotation area was idle each season as summer fallow. It is generally conceded that the yields of grain are now smaller than when the land was first brought into cultivation and that the soil is growing more compact and harder to work with each succeeding year. It is generally believed that the practice of summer fallowing is largely responsible for this condition.

The amount of land idle as summer fallow and the per acre yield of crops were found to be the most potent factors influencing farm profits. Farms having the most summer fallow made the least profit, while those having the largest per acre yield of crops made the largest profits. Any cropping system, therefore, which will increase the per acre yield of crops or do away with summer fallow without decreasing yields should materially increase farm profits.

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On the silt loam soils of the Willamette Valley, Oregon, where climatic conditions are very similar to those of the Bitter Root and Blue Mountain regions, summer fallowing has been discontinued, without a decrease in yields. This result was accomplished through the use of legumes, principally clover, in the rotation. Recent studies show that the same result may be accomplished by the use of clover in that portion of eastern Washington, eastern Oregon, and northern Idaho having an annual precipitation in excess of 20 inches.

The fact that farmers in this section do not use more clover in the crop rotation is due, in large measure, to the prevailing idea that it can not be seeded in a nurse crop. In a study of this method of seeding clover the author found that in 100 trials, covering a period of 11 years, 1,507 acres of land in this region were seeded to clover with wheat, oats, or barley. A good stand of clover was secured on 1,408 acres, or 93.8 per cent of the total acreage seeded.

It was found that for successfully seeding clover with a nurse crop the following rules must be followed: (1) Use good seed; (2) the land must be free from weeds, especially wild oats; (3) the seed bed must be well prepared; (4) but about two-thirds as much grain (nurse crop) should be sown per acre as when no clover is sown; (5) seed early in the spring; and (6) inoculate the soil with nitrogen gathering bacteria, which will grow on the clover plant.

The per acre crop yields on farms where clover has been grown in the crop rotation is from 15 to 25 per cent larger than on farms where the summer-fallow method of growing wheat, oats, or barley is practiced. Three- and four-year rotations with clover are being carried on successfully in different sections of the above-described territory.

FACTORS INFLUENCING FARM PROFITS.

All farm-management studies show that there are certain factors within the control of the farmer which largely determine the profitableness of his business. As stated above, the most potent factors influencing profits on the farms studied in eastern Washington, eastern Oregon, and northern Idaho, as shown by the 1915 survey, were the amount of idle land in summer fallow and the per-acre yield of crops. The greater the percentage of rotation area in summer fallow, the smaller were the profits; the larger the crop yields per acre, the greater the profits. The effect of these factors on farm profits is shown in Tables I and II, which were taken from the 1915 survey of the above-described territory.

It will be seen from Table I that the group of farms having an average of 6.4 per cent of their rotation area devoted to summer fallow had an average of $490 labor income after deducting 8 per cent on capital invested.[1] On the other hand, the group of farms which had an average of 46.5 per cent of their rotation area in summer fallow lacked $200 per farm of making 8 per cent on investment. Those farms with only 6.4 per cent of the rotation area in summer fallow made an average of 8.3 per cent interest on capital invested as compared with 5.9 per cent on farms having 46.5 per cent of the rotation area in summer fallow. It is evident from the crop yields of the different farm groups (see "Crop index," Table I) that the variation in profits in this case is not due to crop yield. The same 246 farms are grouped, however, on a basis of crop yields in Table II and the influence of this factor on farm profits brought out.

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[1] Eight per cent was the current rate on farm loans in this region in 1915.

Table I.—*Percentage of rotation area in summer fallow in relation to profits on 246 farms in eastern Washington, eastern Oregon, and northern Idaho.*

Percentage of rotation area in summer fallow.	Average percentage rotation area in fallow.	Number of farms.	Labor income.[a]	Interest on investment.	Crop index.[b]
					Per cent.
Under 20 per cent	6.4	65	$490	8.3	98.2
20 to 30 per cent	25.6	62	302	7.5	101.0
30 to 40 per cent	34.8	70	− 20	6.3	102.4
Over 40 per cent	46.5	49	−200	5.9	96.8

[a] Labor income.—What the farmer has left after all expenses have been charged, including interest on the money he has tied up in his farm business.
[b] Crop index.—Crop yields as compared with the average of all farms, which is taken as 100 per cent.

Table II.—*Crop yields in relation to profits on 246 farms in eastern Washington, eastern Oregon, and northern Idaho.*

Farm group.	Number of farms.	Average crop index.	Labor income.	Percentage made on investment.	Percentage rotation area in summer fallow.
CROP INDEX.					
Under 90	65	79	−$220	5.5	28.7
90 to 99	62	94	105	6.6	29.6
100 to 110	54	104	297	7.5	32.1
Over 110	65	122	480	8.2	30.6

It will be observed from Table II that the farms with an average crop yield of but 79 per cent of the average of all farms lacked $220 of returning an interest of 8 per cent on the investment (minus $220 in "Labor income" column). As the per-acre yield of crops increases in the succeeding farm groups, the profits also increase until those farms having an average crop index of 122 made a labor income of $480 after deducting 8 per cent interest on capital invested. The interest made on capital for the farm group having the smallest crop index was 5.5 per cent compared with 8.2 per cent for the farm group having the highest yields per acre. The farms with an average crop index of 122 made a 27 per cent larger return on capital invested than did the farms with an average crop index of only 79. The table also shows that in this case the variation in profits for the farm groups was not due to the difference in the percentage of rotation area in summer fallow.

It will be seen from the two foregoing tables that any cropping system which either will increase yields or reduce the amount of land devoted to summer fallow without decreasing the crop yields will materially increase farm profits on these farms. It will, therefore, be the purpose of the following pages to present methods of crop improvement through the use of proper cropping systems, and also to show how the percentage of rotation area in summer fallow may be reduced without materially affecting the yields.

METHODS OF INCREASING FARM PROFITS.

The effect on crop yields of eliminating summer fallow from the rotation was shown in a farm survey on the silt loam soil farms of the Willamette Valley, Oregon. For more than 40 years this section grew wheat and oats by the summer fallow system. The farm practice followed during this period was almost identical with that of eastern Washington, eastern Oregon, and northern Idaho at the present time. The crop yields gradually decreased from year to year until farming became so unprofitable that a change had to be made in the cropping systems. Legumes were introduced into the crop rotation and the amount of land devoted to summer fallow was decreased until in 1912 only 2.7 per cent of the rotation area was idle.

TABLE III.—*Relation of summer fallow to crop yields on 144 silt loam soil farms in the Willamette Valley, Oreg.*

Item.	Farms without summer fallow.	Farms with summer fallow.
Number of farms	127	17
Average yields per acre:		
Potatoes (bushels)	155.9	98.4
Wheat (bushels)	21.9	23.5
Oats (bushels)	37.9	36.5
Hay (tons)	1.94	1.76
Crop index	101	96

In Table III is given a comparison of per-acre yields between farms having summer fallow and those having none in the Willamette Valley. It will be seen that farmers on the silt loam soil in the Willamette Valley eliminated summer fallow from their rotation without reducing the average crop yield. Wheat was the only crop which produced more per acre on farms with summer fallow than on those without. These results were accomplished through the introduction of legumes, principally clover, into the rotation.

TABLE IV.—*Relation of field crop area in legumes to crop yields per acre on 144 silt loam soil farms in the Willamette Valley, Oreg.*

[Farms grouped according to percentage of field crop area in legumes.[a]]

Item.	None.	Under 18 per cent.	18 to 33 per cent.	Over 33 per cent.	All farms.
Average percentage crop area in legumes	None	12.0	26.0	44.8	20.4
Number of farms	35	37	37	35	144
Average yields per acre:					
Potatoes (bushels)	132.8	145.5	172.0	183.5	150.2
Wheat (bushels)	18.8	21.5	23.8	23.7	22.0
Oats (bushels)	28.5	38.3	40.9	44.5	37.7
Hay (tons)	1.82	2.00	1.86	2.07	1.94
Crop index	82.8	100.4	105.0	111.4	100.0

[a] Clover occupied 58 per cent of the area in legumes.

TABLE V.—*Percentage of field crop area in clover in relation to farm profits and yields on 144 silt loam soil farms in the Willamette Valley, Oreg.*

[Farms grouped according to percentage of field crop area in clover.]

Item.	None.	Less than 20 per cent.	More than 20 per cent.	All farms.
Average percentage of field crop area in clover	None.	11.2	32.7	11.7
Number of farms	64	42	38	144
Average capital	$20,547	$22,920	$21,372	$21,457
Average farm income	$1,098	$1,546	$1,834	$1,425
Average labor income	−$135	$171	$560	$138
Average per cent made on investment[a]	5.34	6.75	8.63	6.64
Crop index	95.8	102.7	110.7	100.0

[a] Per cent made on investment in this table means per cent farm income is of capital.

The relation of field crop area in legumes to crop yields is shown in Table IV. The per acre yields of the four principal crops, potatoes, wheat, oats, and hay showed a marked increase on farms devoting more than 33 per cent of their rotation area to legumes over the per acre yield of those growing no legumes. The increases in yields in a comparison of the two groups of farms were as follows: Potatoes, 38.2 per cent; wheat, 26.1 per cent; oats, 56.2 per cent; hay, 13.7 per cent. The average increase in yields due to the use of legumes, for all crops, as shown by the crop index, was 34.5 per cent. The largest increase in crop yields occurred in comparing the group having an average of 12 per cent of the crop area devoted to these crops and the group of farms having no legumes. The increase in crop yields as between these two groups amounts to 21.3 per cent, while the increases as between the second and third and the third and fourth groups are 4.7 per cent and 6.1 per cent, respectively. (See Table V.)

The crop index indicates that those farms having more than 20 per cent of their field-crop area in clover had 15.5 per cent larger yields than farms without clover. The group of farms which grew no clover made a minus labor income of $135; that is, the net farm profits lacked $135 of amounting to 6 per cent of the capital invested.[1]

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[1] Six per cent was the current rate on farm loans in this region in 1912.

The groups of farms which devoted less than 20 per cent of their field-crop area to clover made an average of $171 after deducting 6 per cent interest on capital invested, and the group which devoted more than 20 per cent of their field-crop area to clover made an average of $560 each. The increase in profits was due (1) to the increase in yields and (2) to the profitableness of clover-seed production in comparison with other farm crops for the year in which these records were taken (1912). It will also be seen from the interest made on investment that those farms devoting more than 20 per cent of their field crop area to clover used the capital invested in land and equipment 54.2 per cent more efficiently than the farms growing no clover.

The beneficial effect of clover in the rotation is quite generally recognized among the farmers of the moister sections of eastern Washington, eastern Oregon, and northern Idaho. The importance of this crop, however, as a means of maintaining a profitable system of farming and of improving the soil fertility is very much underestimated. The roots and stubble of a good clover crop are said to contain fertilizing elements equivalent per acre to from 3 to 5 tons of barnyard manure. Its value to the soil in supplying organic matter and thus improving the physical condition can not be estimated. A study of Tables III, IV, and V should convince the most skeptical farmers that clover is one of the biggest factors in building up a profitable farm business. The maintenance of soil fertility in the section above described is as much dependent on legumes, especially clover, as are the silt loam soil farms in the Willamette Valley, Oreg. A recent study by the author of a few farms in different parts of this region on which clover is being used in the rotation showed that they were returning from 15 to 25 per cent larger yields than farms not growing this crop.

SEEDING CLOVER WITH A NURSE CROP.

The small acreage devoted to clover in the moister section of eastern Washington, eastern Oregon, and northern Idaho is due in large measure to the prevailing idea that in order to secure a stand this crop must be seeded alone. The labor of preparing the soil and of seeding the crop by this method is practically the same as for small grain. The use of the land is also lost for one year except for the small amount of pasture that can sometimes be obtained. A few farmers in different localities, however, have broken away from this practice and are seeding clover with a grain crop. This method of seeding requires but little more labor than is necessary for seeding grain alone, and the nurse crop returns a profit while the clover is becoming established. The methods used by a number of farmers and their success in seeding clover with a nurse crop was studied during the past four years with the view of determining the feasibility of this method of seeding in this region.

TABLE VI.—*Results of seeding clover with a nurse crop in that portion of eastern Washington, eastern Oregon, and northern Idaho having an annual precipitation of 20 inches or more.*

Nurse crop.	Number of trials.	Acres tried.	Acres success.	Per cent success.
Winter wheat	17	141	107	75.9
Spring wheat	18	294	284	96.5
Oats	33	388	348	89.7
Barley	32	684	669	97.8
Total	100	1,507	1,408	93.4

It will be seen from Table VI that the number of trials and the total number of acres seeded to clover were sufficient for drawing definite conclusions. The trials covered a period of 11 years (from 1904 to 1916, inclusive, with no trials in 1905 or 1908), which is a sufficient length of time to eliminate the question of variation in climatic conditions from season to season. In the 100 trials reported there were 1,507 acres of clover seeded, with four different nurse crops. A good stand was obtained on 1,408 acres, or 93.4 per cent of the area seeded. Barley proved to be the best nurse crop, as a good stand of clover was secured on 97.8 per cent of the area seeded in barley as compared with 96.6 per cent of the area seeded in spring wheat, 89.7 per cent of the area seeded in oats, and 75.9 per cent of the area seeded in winter wheat. The high percentage of failure when clover was seeded in the spring with winter wheat is attributable to the fact that the wheat was too far advanced when the clover was sown. Very good results, however, have been obtained when the clover was sown in the very early spring before the wheat plants began growing.

When clover is to be seeded in the spring with winter wheat, from 8 to 10 pounds of seed per acre is sown and harrowed in before the grain starts growing. If the nurse crop is to be spring grain, the ground should be plowed in the fall or very early spring and worked into a mellow, shallow seed bed 2 or 3 inches in depth. It is very important that the subsurface below this depth be quite firm. From 8 to 10 pounds of clover seed per acre may be sown broadcast by hand or with a wheelbarrow grass seeder after the nurse crop has been seeded. The usual method, however, is to sow the grain and clover at one operation, using a grain drill having a grass-seed attachment. The clover seed should not be run into the grain tubes of the drill, as the seed are liable to be planted to such a depth that the plants will not reach the surface of the ground. The depth of planting should never be greater than 1½ inches. The drag harrow should be run immediately behind the drill. In case the ground is very loose a corrugated roller may be used to advantage in securing a stand of clover.

The field notes taken in connection with this investigation indicate that the factors contributing to the success or failure of clover seeded with a nurse crop are within the control of the farmer. Most of the failures were due to foul land or poor seed-bed preparation. Special care should be taken to have the land free from wild oats or other weeds. The nurse crop was often too thick. It dried out the soil and killed the clover plants before the grain was harvested or left them in such a weakened condition that they were killed by the dry weather which usually comes after harvest time. Poor seed, late seeding, and the lack of proper soil inoculation were elements which caused many failures. The best results are obtained from seeding clover on soil which is inoculated with the proper kind ofnitrogen-gathering bacteria and which is rich in organic matter.

The nitrogen-gathering bacteria are so essential to success that land which has never raised clover should be inoculated; that is, supplied with nitrogen-gathering bacteria which will produce nodules on the roots of the clover plant.

There are two ways of doing this, the pure culture and the field soil methods. Pure cultures may be secured in small quantities from the United States Department of Agriculture or may be purchased in large quantities from commercial dealers or in some States from the agricultural college. Directions for using the cultures go with them. The pure culture method of inoculation usually costs from $0.25 to $2 per acre, while the field-soil method costs practically nothing and entails extra work only in getting inoculated soil. The soil should be gathered from about clover plants which bear nodules on their roots. The soil can then be dried and pulverized in the shade. It may be stored away for months in a dark basement, and for spring seeding it is a good plan to keep a sufficient quantity in this manner to inoculate the amount of seed to be sown the following spring. The seed should be placed on a tight floor and thoroughly dampened with from 2 to 3 quarts of water per bushel. About 2 quarts of the pulverized soil is then sprinkled on the seed as it is shoveled over in order to get a coating of dust on each seed. It is then allowed to dry in the shade and kept from the sunlight until used. If the soil to be used in inoculating clover seed is sandy, the addition of one-fourth of a pound of glue per gallon of water will cause the dirt to stick to the seed better. When the soil is gathered in the spring and can not be dried for pulverizing it may be mixed with water at the rate of about 2 quarts of dirt to 3 gallons of water. The seed is then dampened at the rate of about 2 quarts of the mixture per bushel and allowed to dry in the shade before sowing.

ROTATION FOR INCREASING PROFITS.

The majority of farmers in those sections of eastern Washington, eastern Oregon, and northern Idaho having an annual precipitation in excess of 20 inches follow a three-year rotation of wheat, oats, or barley, and summer fallow. Many are to be found, however, who have broken away from this type of farming on at least part of the farm and are eliminating the summer fallow on small areas by the use of clover in the rotation. In Nez Perce, Lewis, and Idaho Counties, Idaho, clover is used to quite an extent. A study of the cropping systems of this region shows that clover may be used with as much success there as in the Willamette Valley, Oreg.

The usual method of establishing a crop rotation is to divide the farm into equal parts and change the crop on each field from year to year. For example, a three-year rotation of winter wheat, oats, and clover would be planned as follows:

TABLE VII.—*Usual form of three-field, three-year rotation of winter wheat, oats, and clover.*

Year.	Field A.	Field B.	Field C.
First year	Winter wheat	Oats	Clover.
Second year	Clover	Winter wheat	Oats.
Third year	Oats	Clover	Winter wheat.

On account of the hilly nature of the farm land in the section under discussion fields must be laid out in such a manner as to facilitate the operation of farm machinery. For this reason it is not always easy for the farmer to divide the farm so that an equal area may be devoted to each crop of the rotation. The rotation may be carried out, however, on each field during three successive seasons. The crops to be grown on each field should be so selected that approximately one-third of the farm area is devoted each year to one crop of the rotation.

THREE-YEAR CROPPING SYSTEMS.

The farmers of this section who do not wish to grow intertilled crops may introduce clover by using one of the following cropping systems:

First year.	*Second year.*	*Third year.*
Spring wheat, oats, barley, or field peas. (The grain is seeded as a nurse crop with clover.)	Clover for hay, seed, or pasture.	Spring wheat, oats, barley, or field peas.

Clover is seeded with spring wheat, oats, barley, or field peas during the first year. In the second year the clover which was seeded the previous season is used for hay, seed, or pasture, on ground which will be planted to spring crops the following year. The third year of the rotation is devoted to the growing of winter wheat, spring wheat, oats, or barley. Winter wheat, as already stated, is usually seeded on land which grew clover until about May 1 and was then summer-fallowed, although spring crops may be used. Spring wheat, oats, barley, or field peas give best results on ground from which the clover was used for hay, seed, or pasture.

Farmers who wish to grow intertilled crops instead of summer fallowing their land may use one of the following systems:

First year.	*Second year.*	*Third year.*
Corn, beans, potatoes, or field peas planted in rows and intertilled.	Winter wheat, spring wheat, oats, barley, or field peas. (Grain is seeded as a nurse crop with clover.)	Clover for hay, seed, or pasture.

The first year of these cropping systems is devoted to the growing of corn, beans, potatoes, or field peas planted in rows and intertilled. In those sections where the climatic conditions are unfavorable for growing corn or beans the farmers must depend on potatoes or field peas for an intertilled crop. During the second year of this cropping system the ground from which the crop can be harvested in time for fall seeding may be used for winter wheat. The pea and bean crops may always be harvested in time to permit fall seeding, but unless the corn crop is cut for ensilage or for fodder and hauled from the field, spring grain must be sown. Winter grain is sometimes seeded, however, in the standing corn with a one-horse, five-hoe grain drill, and the corn crop husked from the standing stalk in the usual manner. As a rule, potatoes may be dug early enough to permit fall seeding unless they are very late in maturing. Spring wheat, oats, barley, or field peas all do exceptionally well on land which was devoted to intertilled crops the previous season. In using any of the above crops it must be remembered that they are to be sown as a nurse crop with clover. The third year of the rotation the clover is used for hay, seed, or pasture. It is very important that clover land be plowed in the fall when possible to do so.

FOUR-YEAR CROPPING SYSTEMS.

Many farmers in the above-described territory wish to summer fallow or grow a cultivated crop on the land once in four years. In order to include clover in this sort of rotation one of the following four-year cropping systems may be used:

First year.	*Second year.*	*Third year.*	*Fourth year.*
Corn, beans, potatoes, or field peas planted in rows and cultivated in rows; summer fallow.	Winter wheat, spring wheat, oats, barley, or field peas.	Spring wheat, oats, barley, or field peas. (Grain seeded as a nurse crop with clover.)	Clover for hay, seed, or pasture.

For farmers who wish to use intertilled crops instead of summer fallowing, the first two years of this plan are the same as the first two years of the preceding three-year rotations. Farmers who do not wish to grow intertilled crops may substitute summer fallow during the first season. During the third year spring wheat, oats, barley, or field peas is seeded as a nurse crop with clover, and the fourth year the clover is used for seed, hay, or pasture.

CLOVER FOR SEED.

As clover is a comparatively new crop in the moister sections of eastern Washington, eastern Oregon, and northern Idaho, many farmers are not familiar with its use. On every farm it is possible to utilize a limited acreage of this crop for supplying the live stock with hay and pasture. The area so occupied, however, would be small in comparison with the total area under cultivation, as only a small number of animals are kept per farm. Thus it would not be possible to use clover often enough in the rotation materially to affect yields if this were the only way in which it could be used. By growing it for seed as well as for hay or pasture, however, the area devoted to this crop could be increased until from one-fourth to one-third of the tillable land would be devoted to clover every year. That clover seed may be successfully and profitably produced has been proved by several years' experience in parts of Idaho, Lewis, and Nez Perce Counties, Idaho. Seed production was started in eastern Nez Perce County in 1908 and the first clover seed huller was brought into the county a year later. The amount of land devoted to clover seed production gradually increased until in 1916 six clover hullers were necessary to care for the seed crops. The farmers who have grown seed find not only that it is a profitable crop but that the subsequent grain crops yield from 15 to 25 per cent per acre more than from land where clover was never produced.

PUBLICATIONS OF THE UNITED STATES DEPARTMENT OF AGRICULTURE RELATING TO GRAIN AND FORAGE CROPS.

PUBLICATIONS AVAILABLE FOR FREE DISTRIBUTION BY THE DEPARTMENT.

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Lespedeza, or Japan Clover. (Farmers' Bulletin No. 441.)
Red Clover. (Farmers' Bulletin No. 455.)
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Crimson Clover: Utilization. (Farmers' Bulletin No. 579.)
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Grains for the Dry Lands of Central Oregon. (Farmers' Bulletin No. 800.)
Growing Winter Wheat on the Great Plains. (Farmers' Bulletin No. 895.)

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Forage-Crop Practices in Western Oregon and Western Washington. (Farmers' Bulletin No. 271.) Price, 5 cents.
Farm Practice in Columbia Basin Uplands. (Farmers' Bulletin No. 294.) Price, 5 cents.
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Grimm Alfalfa and Its Utilization in the Northwest. (Bureau Plant Industry Bulletin No. 209.) Price, 10 cents.
Clover-seed Production in Willamette Valley, Oreg. (Bureau Plant Industry Circular No. 28.) Price, 5 cents.

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